Mars Surveyor Project

Mars Volatiles and Climate Surveyor (MVACS) Experiment Data Record (EDR)

Software Interface Specification (SIS)

Version 2.2

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ACRONYMS AND ABBREVIATIONS

AIM	Attitude and Information Management
ASCII	American Standard Code for Information Interchange
CAHV	Camera model described by four vectors C, A, H and V
CAHVOR	Camera model CAHV with radial image distortions taken into account
CCD	Charge-Coupled Device
EDR	Experiment Data Record
FEI	File Exchange Interface
ICD	Interface Control Document
JPEG	Joint Photographic Experts Group
LMA	Lockheed-Martin Aerospace
LPL	Lunar and Planetary Laboraroty, University of Arizona at Tucson
MFX	Mars Surface Fixed coordinate frame
MIPL	Multimission Image Processing Laboratory
MIPS	Multimission Image Processing Subsystem (old name for MIPL)
MSOP	Mars Surveyor Operations Project
MSP98	Mars Surveyor Project
MVACS	Mars Volatiles and Climate Surveyor
NAIF	Navigation and Ancillary Information Facility
PDS	Planetary Data System
RA	Robotic Arm
RAC	Robotic Arm Camera
SFDU	Standard Formatted Data Unit
SIS	Software Interface Specification
SSI	Surface Stereo Imager
TBD	To Be Determined
UA-LPL	University of Arizona, Tucson
VICAR	Video Image Communication and Retrieval system
WMS	Working Mission Storage

1.0 INTRODUCTION

This specification describes the image data products to be delivered to the Imager for Mars Volatiles and Climate Surveyor (MVACS) Team of the Mars Surveyor Project (MSP98) by the Multimission Image Processing Laboratory (MIPL). The specifications of the software that produce the products described herein are beyond the scope of this document. Applicable documents used in producing this specification include:

- Planetary Data System Standards Reference, JPL D-7669, Part 2.
- Planetary Science Data Dictionary Document, JPL D-7116, Rev D.
- VICAR File Format, JPL, R. Deen, Interoffice Memorandum 384-92-196, September 1992.
- SSI Calibration Report, University of Arizona, http://imp.lpl.arizona.edu/mvacs_Team/Cal/Report/
- DISRSOFT Image Processing Document, N. Thomas, J. Stüwe, Max-Planck Institute for Aeronomie, Version 1.5, July 12, 1994.
- MVACS Flight Software Command Format, University of Arizona, http://imp.lpl.arizona.edu/mvacs_Team/Docs/ssi
- Users Guide to The Stereo Surface Imager, Version 1.0, University of Arizona, http://imp.lpl.arizona.edu/mvacs_Team/Docs/ssi
- PDS detached label template, TBD
- Mars Surveryor Program '98 - Lander, AACS Hardware Coordinate Frame Definitions and Transformations, Lockheed-Martin, Revision #1, 11/16/98
- Mars Polar Lander Frame definition Kernel, ftp://naif.jpl.nasa.gov/pub/naif/MPL/kernels/fk/mpl40.tf
- "MPL Coordinate System Reference" document provided by Stephen "Mitch" Micciche, SCOPS/LMA on October 21, 1999.

1.1 Notation

This documentation uses the "Committee on Data Management and Computation" (CODMAC) data level numbering system. The data files referred to in this document are considered "level 2" or "Edited Data" (equivalent to NASA level 0). The data files are generated from "level 1" or "Raw Data" which is the telemetry packets within the project specific Standard Formatted Data Unit (SFDU) record.

1.2 Product and Transfer Mechanism

The image data files and labels generated by MIPL software for Mars Surveyor will be transferred electronically to the MVACS Team via the File Exchange Interface (FEI). Each image file will be generated as a VICAR labeled file. A separate, Planetary Data System (PDS) data file will be associated with each image file, for delivery to PDS. This type of file will be delivered to or generated by the MVACS Team upon request. The image data files may be generated on any one of the following platforms: Sun SPARCstation running Solaris, or Silicon Graphics running IRIX.

1.3 Image Data Processing

In order to understand the image processing and nomenclature of the data products, it is useful to understand how the SSI and RAC cameras operate. Figure 1.1 shows a diagram of how an SSI image is captured and retrieved by the SSI camera. The main points to note are that the stereo images are rotated differently on the CCD chip and that the flight software operates on the CCD's coordinate frame not the images'. There are also additional CCD elements that are used to help correct for dark current and shutter effects. Figure 1.2 shows how a RAC image is captured and retrieved by the Robotic Arm Camera.

After the SSI "exposes" the imaging portion of the CCD, the image is shifted into a storage area of the CCD where it will not accumulate more exposure (there is no mechanical shutter on the SSI or RAC). The data in the storage area is then moved into a shift register that will read out the image data and the CCD calibration elements. The full size of the SSI image area the flight software can process is a 256 by 256 area. In order to minimize border effects between different imaging components (left, right and dark pixel regions), only 248 lines are normally processed.

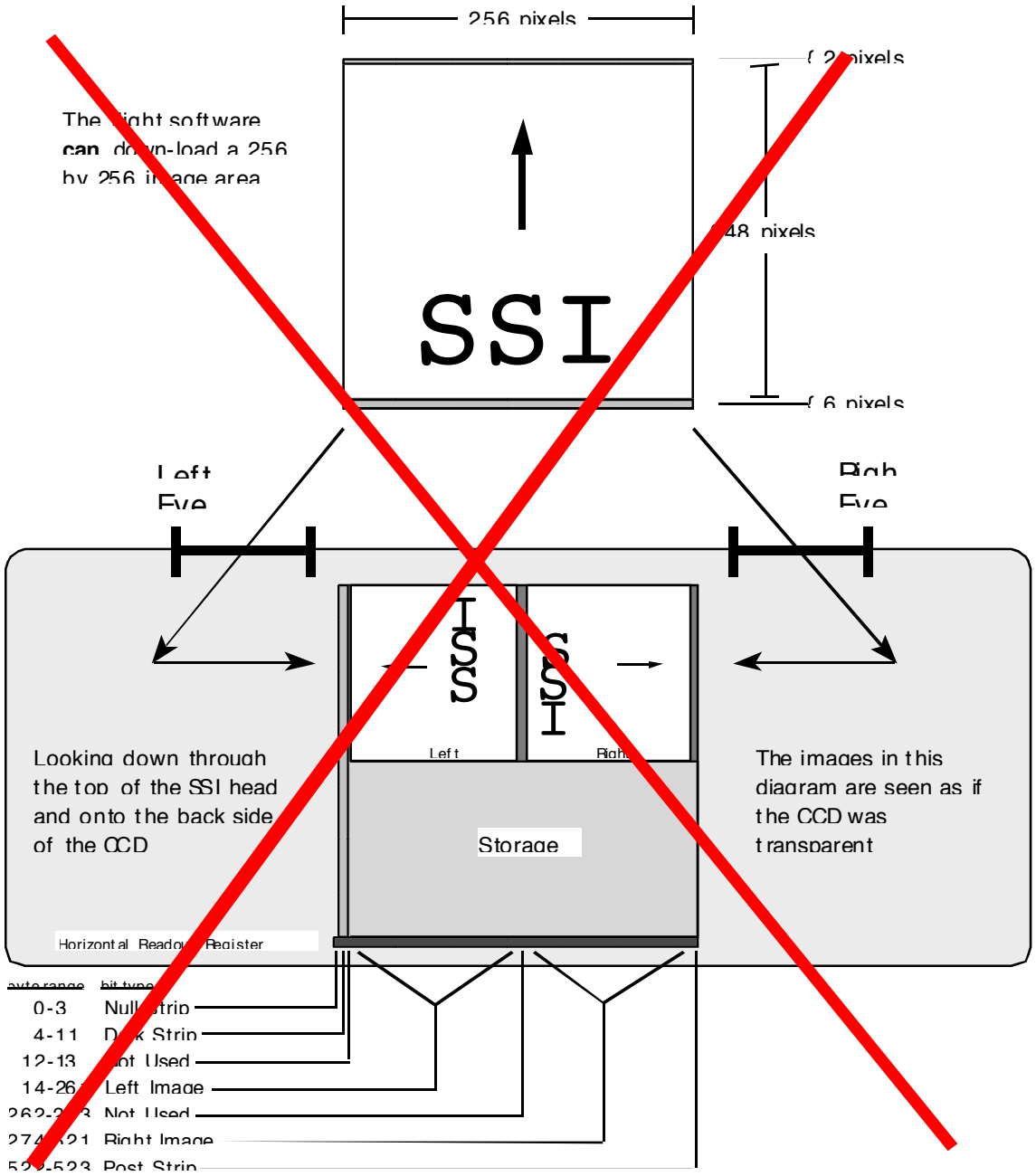

Figure 1.1 — *SSI Image Capture and Retrieval*

This diagram shows the basic structure of the SSI camera head and how a scene is imaged. Various components are shown for reference purposes. This diagram is for schematic purposes only; significant liberties have been taken regarding the geometry of the components.

The data packaged in the data files will be decoded, decompressed SSI or RAC image data in single frame form as an Experiment Data Record (EDR). The single frame from a standard SSI image data file has a maximum dimensions of 256 lines by 256 samples. A single frame from a standard RAC image data file has a maximum dimension of 256 lines by 512 samples. The other image data files and their data sizes are listed in Table 1.1. Single image frames can be mosaiced to produce a larger image. The VICAR software used to generate the image data set products is described in Table 1.2.

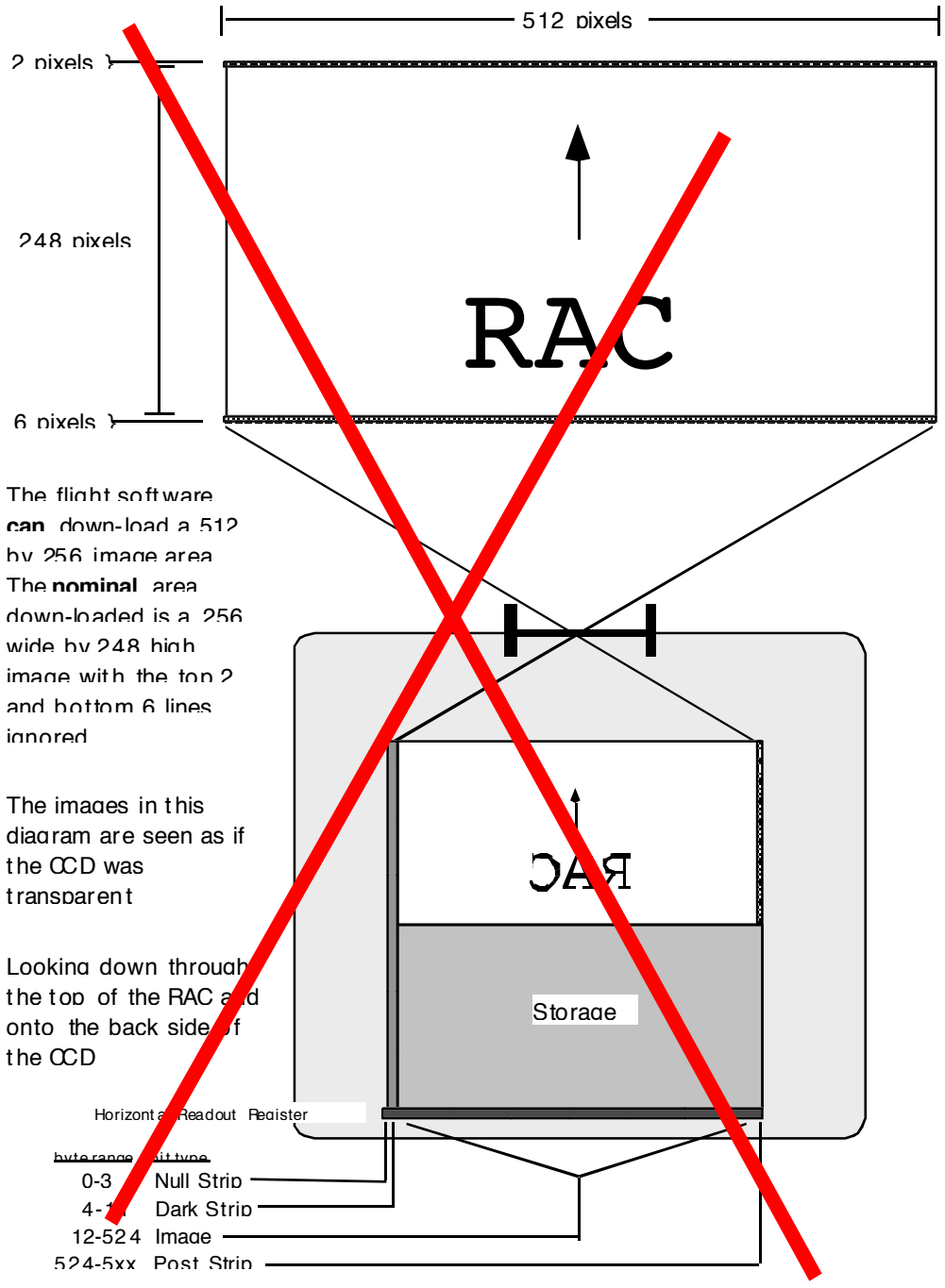

Figure 1.2 — *RAC Image Capture and Retrieval*
This diagram shows the basic structure of the RAC camera head and how a scene is imaged. Various components are shown for reference purposes. This diagram is for

schematic purposes only; significant liberties have been taken regarding the geometry of the components.

As mentioned, the SSI commands use CCD coordinates, while the EDR refers to image coordinates (rotated with respect to the CCD coordinates). All EDR images are annotated with sub-framing information (even for full frame images). Where Line and Sample '1' are in the upper left corner of a rotated image (up is pointing up, not to a side). The nominal image frame of the SSI starts at line 1 sample 1, consisting of 256 lines by 256 samples.

Table 1.1. — *Maximum data set size for Mars Surveyor MVACS Image Data Files*

Image Type	***Image Size*** *lines x samples*	***Pixel Size*** *(bits)*	***Description***
Image Data *regular observations*	256 x 256 (SSI) 256 x 512 (RAC)	16	Image data is unsigned and rotated from the CCD frame. SSI: Right images have been rotated counter-clockwise, left images have been rotated clockwise.
Dark Strip	256 x 8	16	Calibration data retrieved from a dark strip area of the CCD.
Null Strip	256 x 4	16	Calibration data retrieved from the readout register of the SSI/RAC camera.
Post Null Strip	256 x 4	16	Calibration data retrieved from the post strip of the SSI/RAC camera.
Flat Field *special observations used for calibration*	256 x 256 (SSI) 256.x.512 (RAC)	16	Flat Field data is unsigned and rotated from the CCD frame. SSI: Right images have been rotated counter-clockwise, left images have been rotated clockwise.
Dark Field *Also referred to as Dark Current; special observations used for calibration*	256 x 256 (SSI)	16	Dark Field data is unsigned and rotated from the CCD frame. SSI: Right images have been rotated counter-clockwise, left images have been rotated clockwise. RAC: no dark field images
Histogram	1 x 4096	16	Histogram data contains a 4096 element histogram table. Each sample corresponds to the count of DN values in the target image.

Summed	2 x 256 (SSI) 2 x 512 (RAC)	32	All rows and columns are summed. The first record is the result of the row summing where each sample the sum of all the pixels from the corresponding row. The second record is the result of column summing.

NOTE: Due to on-board JPEG compression, it is possible to generate DN values greater than 4095 (the largest value the camera electronics can generate). This is due to the lossy compression algorithm of the JPEG. The label item ERROR_PIXELS will identify the number of pixels that are greater than the nominal 4095 maximum.

Table 1.2. — *VICAR Software for Mars Surveyor MVACS Image Data Files*

Application	Description
M98TELEMPROC	Fetches the image Standard Formatted Data Unit (SFDU) records from the Telemetry Delivery Subsystem (TDS), and reconstructs the image file from the telemetry data. If a version of this image exists in the Working Mission Storage (WMS), the image data is compared to the WMS version. If the new version has more data than the existing version, it replaces the WMS version. This application produces a VICAR image file with a subset of descriptive label items. It also accesses the catalog and SPICE kernels to supplement the ancillary image information from the telemetry data.

1.4 Coordinate System Components

The following paragraphs describe the various coordinate system referenced by number of related label items. It is not the intention of this document to serve as the definitive authority for these coordinate system. They are defined to the extend necessary by the MIPL's mosaic programs. Full definition of the coordinate systems is outside the scope of this document.

Please see the list of applicable documents in section 1 for further references.

1.4.1 MPL Landed Local Vertical, Local Horizontal (LLVLH) Frame

This frame is primarily used by the spacecraft team at Lockheed-Martin. None of the values within the EDR reference this coordinate system.

This is the frame with respect to which the landed lander orientation is determined by the on-board Gyro Compass process. The frame is defined by "MPL Coordinate System Reference" document as follows:

> "The Landed Local Vertical, Local Horizontal Coordinate System used by the Lander is a coordinate system [the origin of which is -- BVS] fixed with respect to the landed spacecraft. The coordinate frame is related to the MCI [MARSIAU Inertial -- BVS] frame by rotation of the right ascension of the Mars local meridian and the latitude of the landed spacecraft."

The lander orientation quaternion provided by LMA refers to this coordinate system, but the quaternion is transformed by the MVACS team into the MVACS and local level frames before telemetry is processed so LLVLH never appears in the EDR.

Note: This frame is similar to local level, but differs in the origin point and a 180° rotation about the X-axis (Z points down, while local level Z points up).

1.4.2 Surface Fixed Frame

This frame is oriented identically to local level, with X pointing to local North, and Z pointing up. The origin is defined as being identical to the local level at the moment of landing and it never moves (is fixed) relative to the Martian surface.
If the lander moves after landing, the SRFC_FXD_LCL_LVL_VECTOR defines the translation between surface fixed and the local level frame.

1.4.3 Local Level Frame

This frame defines the Z axis as the normal outward at the landing site (up), the X axis points at local north with the Y-axis completing the right handed frame. Positive azimuth is measured counter clockwise from the x axis.

Orientation of the frame is given relative to the Mars fixed rotating frame 'IAU_MARS' (x - along the line of zero longitude intersecting the equator, z - along the spin axis, y - completing the right hand coordinate frame)

The origin of the local level frame is fixed to the lander (contrast with surface fixed, which is fixed to Mars). It has the same X and Y origin as the lander frame, with the Z origin near the ground at a fixed offset relative do the lander frame of 1.643 meters. That is, the coordinates of the local level origin measured in the lander frame are (0, 0, 1.643).

Note: The actual point defining the origin was arbitrary, but it refers to a survey point taken during ATLO, which was "screw on lander foot".

1.4.4 Lander Frame (LMA's Lander Mechanical)

The origin of this frame is located above the platform at a distance defined by the "MPL Coordinate System Reference" document. It is fixed relative to the lander, and hence the MVACS fixed. The Z-axis points down and goes through the origin of the local level. X-axis is 180 degrees off with respect to MVACS frame. Y-axis is in the same direction as MVACS frame. (i.e. a 180° rotation about the Y-axis)

1.4.5 MVACS fixed

Th origin is at the base of the SSI mast and is fixed relative to the spacecraft. Z points up, with Y pointing the same as lander (i.e. 180° rotation around Y)

The transformation between MVACS and lander is fixed, and is defined as:

$$
\begin{aligned}
Lander_x &= -MVACS_x - 0.5300 \\
Lander_y &= +MVACS_y - 0.2324 \\
Lander_z &= -MVACS_z + 0.7995
\end{aligned}
$$

The rotation between MVACS and local level is given by MVACS_LOCAL_LEVEL_QUATERNION.

1.5 Quaternion

The quaternion is the coordinate transform or rotation between the MVACS Frame and the Local Level Frame. The VICAR label defines the quaternion using the NAIF notation of the cosine of the rotation angle followed by the sine of the rotation angle multiplied by each component of the unit vector of the axis of rotation.

The following brief excerpt discussing quaternions was taken from the NAIF distributed SPICELIB documentation:

> Quaternions are four dimensional vectors, on which a particular kind of arithmetic is defined. The quaternions that have norm equal to 1 are called 'unit quaternions'. Unit quaternions may be associated with rotations in the following way: if a rotation R has unit vector n = (n1, n2, n3) as an axis and w as a rotation angle, then we represent R by
>
> $$Q = (\cos(w/2),\ \sin(w/2)\ n1,\ \sin(w/2)\ n2,\ \sin(w/2)\ n3)$$
>
> As you might suspect, this association is not unique: substituting (w + 2*pi) for w, we see that -Q is also a representation for R. If we choose the rotation axis and angle of R so that the angle lies in [0, pi], then there is a unique quaternion representing R, except in the case where R is a rotation by pi radians.
>
> The main interest of quaternion multiplication is that we can actually carry out composition of rotations using the multiplication defined on the quaternions. If quaternions Q1 and Q2 represent rotations R1 and R2, then Q2*Q1 represents R2(R1). So the mapping from unit quaternions to rotations is a group homomorphism, where the 'multiplication' operation on the rotations is functional composition.

2.0 DETAILED SPECIFICATION

The following section describes in greater detail the files to be received by the SSI Team.

2.1 Structure and Organization Overview

For each archived SSI or RAC image, one file is created, a VICAR image data file with a detached PDS label. This file constitutes data product to be managed and archived by MIPL as one unit.

The image data will be a single image frame captured by the MVACS cameras. The maximum size of the SSI image frame is 256 lines by 256 samples, however, the nominal image frame size is 248 lines by 256 samples. The construction of the SSI camera created an area of overlap between the right and left image views and the elimination of 8 lines from each removes this artifact. The RAC maximum image size is 256 lines by 512 samples.

2.1.1 MIPL Local Image File

An image file consists of two major parts: the image header, which describes many aspects of the image, and the image area, which contains the actual image data The image header and image area are stored as a standard VICAR image. Additional information about the basic VICAR image structure and content is described in the "VICAR File Format" document (reference 4). The line and sample numbering of the image data starts with an origin of (1,1) at the upper left of the image with increasing values both to the right and down. See figure 2.1 for a graphical representation of a nominal SSI EDR. The RAC structure is very similar, only the image area will be enlarged to contain the 256 x 512 maximum image size.

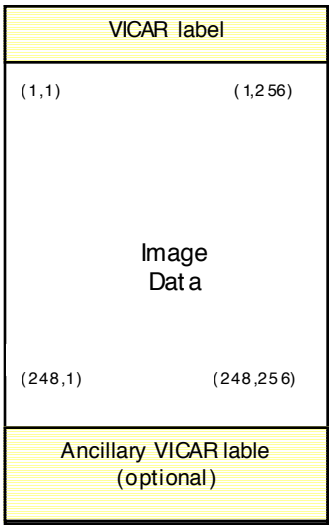

Figure 2.1 — *VICAR Image Organization*

This figure identifies the basic structure of the VICAR SSI EDR data file. There is an ASCII label at the beginning of the file followed by the image data and an optional ancillary VICAR label in cases where not enough space was allocated for the label at the beginning of the file.

2.1.2 PDS Archived detached Label File

Every archived image data file has a corresponding detached PDS label file. This label conforms to the Planetary Data System standard for ancillary data management. The label contains information regarding the observation which produced the image. This observation information includes general descriptors such as observation sequence name and time tags of the start of image acquisition, camera and spacecraft state parameters, data compression information, viewing and lighting geometry, spacecraft position and camera pointing, image dimensions, and processing history.

For an example of a PDS detached label template see document TBD.

2.2 File Naming Conventions

The following naming convention standard for MVACS image data files is to be maintained by MIPL as a means of files management.

2.2.1 VICAR Image Data File Names

For all data files stored in the MIPL Working Mission Storage (WMS), the filenames will be constructed with five parts as shown below in Figure 2.3.

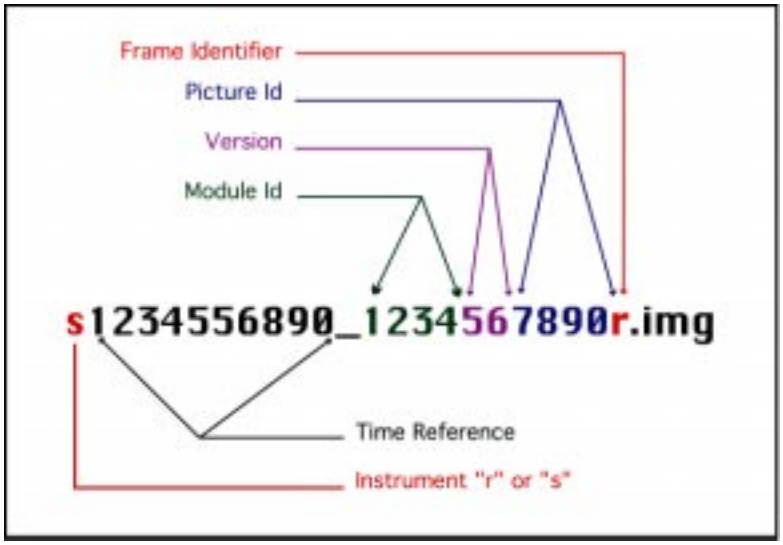

Figure 2.3. — *Sample VICAR Image File Name*

Instrument Identifier - The instrument identifier will be either the lowercase letter ‘s’ or 'r', representing an EDR from the SSI or RAC cameras respectively.

Time Reference Number - The time reference number will be the 10-digit Spacecraft Clock Start Count, as described in Appendix A. The Spacecraft Clock Start Count is the same for left, right, null strip and dark strip images.

Image Reference Number - The image reference number is the 10-digit Image ID appended onto the file extension. The reference number is procedurally divided into three parts, the module ID, version and picture ID. The sequence ID is the most significant 4 digits, the version the middle two digits and the picture ID the least significant 4 digits.

Frame Identifier - The frame identifier will be a one character letter, ‘l’, ‘r’, 'm', ‘d’, ‘n’, or 'p' referring to an image generated from the left, right, monocular (RAC) , dark strip, null strip or post strip frame respectively.

File Extension - The file extension is the three character extension 'img'.

2.2.2 PDS Detached Label File Names

The PDS detached label filenames will be constructed identically to the VICAR image data filename except for the file extension, shown below in Figure 2.4.

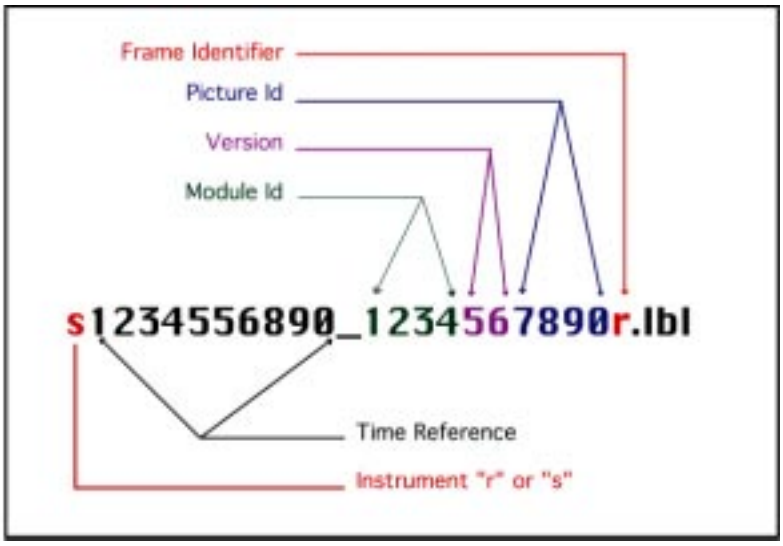

Figure 2.4. — *Sample PDS Detached Label File Name*

APPENDIX A: SSI PDS/VICAR EDR Label Items

A.1 SSI PDS/VICAR EDR Label Items

The following table lists all the label items which will appear in the VICAR labels associated with each image file generated by the MIPL real-time telemetry processing system.

If the value of a particular item can not be determined, a default value or place holder is used instead. See descriptions of each item for detailed values. These values are defined in PDS null definitions described in standard "C" header file named "pds_nulls.h" attached as Appendix C. Blank value in the "default" column indicates that a physical value always exists.

The "Source" column defines the origin, or source of information, for a particular item. Some entries are combination of several sources depending on source of raw and computed information.

EK	Obtained from E-Kernel. *Overwritten if also available from TLM.*
GDS	Ground Data System headers included all headers added by DSN and upstream processing.
MIPL	Computed/derived/generated by MIPL telemetry software or other internal procedures. For example, current time of day or the name associated with a filter number.
MVACS	Provided by MVACS, imaging team, post R/T.
NAIF	Computed by MIPL using NAIF toolkit or executable programs. Note that E-Kernel is identified separately.
PDS	Value supplied from PDS central or imaging node
TBD	Unknown source. Needs to be resolved.
TLM	Downlink telemetry data stream

Label Name	Description	type	valid	Default	Property	Source
APPLICATION_PACKET_ID	Classifies the telemetry packet from which the image data was obtained. This packet ID is extracted from the telemetry download. This value is based on a set of values specified in the Downlink Telemetry Documents (JPL). This acronym is APID.	integer			telemetry	TLM:apid
APPLICATION_PACKET_NAME	Group name associated with APID.	string	One of the following: • SSI ATMOSPHERIC • SSI CALIBRATION • SSI ERROR • SSI GEOLOGICAL 1 • SSI GEOLOGICAL 2 • SSI GEOLOGICAL 3 • SSI GEOLOGICAL 4 • SSI LANDER • SSI MAGNETS • SSI MESSAGE • SSI RAC 1 • SSI RAC 2 • SSI RAC 3 • SSI RAC 4		telemetry	MIPL
AUTO_EXPOSURE_DATA_CUT	A value indicating the base for pixel values using AUTO_EXPOSURE_PIXEL_FRACTION as the percentage of pixels wanted above that value. This field is valid if EXPOSURE_TYPE is "AUTO".	integer	[0, 4095]	NULL	command	EK:SSI_DATA_NUM

Label Name	*Description*	*type*	*valid*	*Default*	*Property*	*Source*
AUTO_EXPOSURE_PIXEL_FRACTION	Fraction of pixels wanted to exceed AUTO_EXPOSURE_DATA_CUT, expressed as a percentage. This field is valid only if EXPOSURE_TYPE is AUTO.	real	[0, 100.0]	PDS_FLOAT_NA	command	EK:SSI_PIXEL_FRAC
AZIMUTH_FOV	The angular coverage of the imaged scene measured horizontally with respect to the image plane in spacecraft coordinates. This is a simple multiplication of the number of samples by the field of view of each pixel. For the RAC, this calculation will include factoring the instrument focal length too. The conversion factor is fixed at 0.0547°/pixel	real	[0.0, 360.0]		instrument state	MIPL (based on image size)
BAD_PIXEL_REPLACEMENT_FLAG	Indicates whether or not bad pixel replacement processing command was issued to the flight software. If set TRUE, certain pixels of the image will be replaced based on a bad pixel table.	string	TRUE,FALSE	NULL	command	EK:SSI_BAD_PIX_FLAG
BANDS	Number of image bands. Used only for multi spectrum images.	integer	1		image data	MIPL
CALIBRATION_SOURCE_ID	An identifier indicating the calibration method used in generating the static camera model	string			derived camera model	MIPL
CAMERA_MODEL_DESC	A textual description of this model_type, or a pointer to a MIPL internal file containing the description. These files are added as new camera models are adopted.	string			derived camera model	MIPL
CAMERA_MODEL_NAME	An identifier which uniquely distinguishes this camera model object from other camera model objects included in the same file; ex. "MIPS-0" or "TELEMETRY"	string			derived camera model	MIPL
CAMERA_MODEL_TYPE	Identifies the type of camera model being represented. (i.e., CAHV, CAHVOR, CAHVORE, other).	string			derived camera model	MIPL

Label Name	*Description*	*type*	*valid*	*Default*	*Property*	*Source*
COMMAND_DESC	Text which describes the uplinked command as found in COMMAND_NAME element from FEF. This value will be stored post real-time.	string		NULL	command	MIPL
COMMAND_NAME	Uplinked command name as found in the Mars Polar Lander Command Dictionary.	string	"SSI_IMAGE"		command	MIPL
COORDINATE_SYSTEM_NAME	An identifier indicating the coordinate system used in generating the camera model	string	"MPL_MVACS"		derived camera model	MIPL
DARK_CURRENT_CORRECTION_FLAG	Indicates that dark current correction processing command was issued to the flight software and the image is to be adjusted by an on-board dark current correction image. SSI only	string	TRUE, FALSE	NULL N/A (RAC)	command	EK:SSI_DARK_CUR_FLAG
DATA_SET_ID	A unique alphanumeric identifier for a data set or a data product. This identifier consists of the identifiers for spacecraft, target, instrument, processing level, product acronym, and version number.	string	"MPL-M-SSI-2-EDR-V1.0" "MPL-M-RAC-2-EDR-V1.0"		identification	PDS
DATA_SET_NAME	Full name given to a data set or product. This is an unabbreviated version of the DATA_SET_ID.	string	“MARS POLAR LANDER MARS SURFACE STEREO IMAGER 2 EDR V1.0” “MARS POLAR LANDER MARS ROBOTIC ARM CAMERA 2 EDR V1.0”		identification	PDS
DERIVED_GEOMETRY_DESC	A textual description of the method used to generate this derived geometry object.	string			derived geometry	MIPL
DERIVED_GEOMETRY_NAME	An identifier which uniquely distinguishes this derived geometry object from other derived geometry objects included in the same file; ex. "MIPS-0" or "TELEMETRY"	string			derived geometry	MIPL

Label Name	Description	type	valid	Default	Property	Source
DERIVED_GEOMETRY_NOTE	A textual description explaining the purpose of this derived geometry object. It may include what fields are different from telemetered values and how they were derived.	string			derived geometry	MIPL
DERIVED_GEOMETRY_TYPE	Identifies the general method used to generate the derived geometry	string	"TELEMETRY" "AUTO_SYSTEMATIC" "INTERACTIVE_SYSTEMATIC" "BACKLASH"		derived geometry	MIPL
DOWNLOAD_TYPE	Command parameter identifying the image data to be downloaded. state of the download flag. Contains any combination of the following mnemonics, separated by comma: • NONE • IMAGE • STRIP • PRENULL • PSTNULL • HIST • SUM • DEPTH	string		NULL	command	MIPL EK:SSI_DOWNLOAD_FLAG
EARTH_RECEIVED_START_TIME	Identifies the earliest time a packet was received that contained data for the image.	string	YYYY-MM-DDThh:mm:ss.fffZ		telemetry	GDS MIPL
EARTH_RECEIVED_STOP_TIME	Identifies the latest time a packet was received that contained data for the image.	string	YYYY-MM-DDThh:mm:ss.fffZ		telemetry	GDS MIPL

Label Name	Description	type	valid	Default	Property	Source
ELEVATION_FOV	The angular coverage of the imaged scene measured vertically with respect to the image plane in spacecraft coordinates. This is a simple multiplication of the number of lines by the field of view of each pixel. For the RAC, this calculation will include factoring the instrument focal length too. The conversion factor is fixed at 0.0547°/pixel	real	[0.0, 90.0]		instrument state	MIPL (based on image size)
EMISSION_ANGLE	The emission_angle element provides the value of the angle between the surface normal vector at the intercept point and a vector from the intercept point to the spacecraft. For this EDR, only the value for center pixel is saved, post real-time. See Appendix D for more detail.	real		PDS_FLOAT_NULL	image geometry	MIPL
ERROR_PIXELS	Count of the number of pixels that are outside of the valid DN range (0 to 4095).	integer			compression	MIPL
EXPECTED_PACKETS	Total number of telemetry packets which constitute a complete image, an image without missing data.	integer	<any positive value>		telemetry	MIPL
EXPOSURE_DURATION	Integration time for manual and auto exposure, measured in milliseconds. Integration Time in SSI Telemetry Format specification from the U. of Arizona. Calculated from EXPOSURE_DURATION_COUNT. Conversion factor is 0.5 milliseconds per DN.	real	[0.0, 32767.5]		instrument state	MIPL
EXPOSURE_DURATION_COUNT	Integration time for manual and auto exposure, measured in raw telemetry counts. Integration Time in SSI Telemetry Format specification from the U. of Arizona.	integer	[0, 65535]		instrument state	TLM:integration_time

Label Name	Description	type	valid	Default	Property	Source
EXPOSURE_TYPE	Exposure type for the image: auto, manual, pre-timed, incremental or none. Auto exposure allows for adjusting the exposure time based on a previous (incremental) exposure. Manual exposure is a single exposure with a set expose time. Pre-timed exposure uses the very last expose time used, regardless of what kind of exposure it was. When used in conjunction with EXPOSURE_DURATION_COUNT equal to '0', pretimed uses the last exposure taken with the same FILTER_NUMBER. No exposure indicates that the command moves only the camera and doesn't take an exposure.	string	One of the following: • AUTO, • INCREMENTAL • MANUAL, • NONE • PRETIMED, • READOUT • READOUT_ALL	NULL	instrument state	EK:SSI_EXPOSE_TYPE
FILTER_NAME	The name of the instrument filter through which the image was acquired. The number in the name refers to the effective wave length in nm of the filter for the left (L) or right (R) image.	string	for flt 0, "L440_R440" for flt 1, "L450_R670" for flt 2, "L885_R947" for flt 3, "L925_R935" for flt 4, "L935_R990" for flt 5, "L670_R670" for flt 6, "L800_R750" for flt 7, "L860_R-DIOPTER" for flt 8, "L900_R600" for flt 9, "L930_R530" for flt 10, "L1000_R480" for flt 11, "L965_R965"	N/A	instrument state	MIPL TLM:filter_or_cover
FILTER_NUMBER	The number of the instrument filter through which the image was acquired.	string	filter number from "0" to "11"	N/A	instrument state	TLM:filter_or_cover
FIRST_LINE	Indicates the line within a source image that corresponds to the first line of the sub-image. See appendix D for more detail.	integer	[1, 256]	PDS_INT_NULL	image data	MIPL EK:SSI_ROW_MIN

Label Name	Description	type	valid	Default	Property	Source
FIRST_LINE_SAMPLE	Indicates the sample within a source image that corresponds to the first sample in the sub-image. See appendix D for more detail.	integer	[1, 256]	PDS_INT_NULL	image data	MIPL EK:SSI_COL_MIN
FLAT_FIELD_CORRECTION_FLAG	Indicates whether or not flat field correction processing command was issued to the flight software. If set TRUE, the image is to be adjusted by an on-board flat field correction image.	string	TURE, FALSE	NULL	command	EK:SSI_FLAT_FIELD
FRAME_ID	Provides an identification for a particular instrument frame (Dark Strip, Left, Monocular, Null Strip, Post Strip or Right)	string	SSI • POST • STRIP • NULL • LEFT • RIGHT RAC • POST • STRIP • NULL • MONOCULAR	NULL	identification	TLM:image_info.data_type
GEOMETRY_SOURCE_ID	Identifies the derived geometry used as input to this camera model. An identifier indicating the source of the navigation / pointing information used in the generation of the camera model	string	"TELEMETRY"		derived camera model	MIPL
IMAGE_ID	10-digit number that uniquely identifies the observation parameters of an image. The most significant 4 digits identify the command module that contains the imaging command. One Image ID can generate up to 5 SSI image data products, and 4 RAC data products, per execution of the imaging command.	string	0 to (2^{31}- 1)		identification	TLM:image_id
IMAGE_TIME	Time at which the image was acquired. In UTC format, this value corresponds to SPACECRAFT_CLOCK_START_COUNT	string	YYYY-MM-DDThh:mm:ss.fffZ		identification	MIPL via NAIF

Label Name	Description	type	valid	Default	Property	Source
IMAGE_TYPE	Image data type as specified in the image packet as image information bits. The image data type defines the format and type of image data. Except for SUMMATION and HISTOGRAM, all the image observation types basically identify normal imaging data, Please refer to section 1.3 for a better discussion of the meaning of these values.	string	One of the following: • ACTIVE_FOCUS • ATMOSHERIC • DARK_CURRENT • DEPTH_FOCUS • HISTOGRAM • REGULAR • SUMMATION		identification	TLM:imge_info.data_type
INCIDENCE_ANGLE	The incidence_angle element provides a measure of the lighting condition at the intercept point. See appendix D for more detail. This value will be save in EDR post real-time.	real		PDS_FLOAT_NULL	image geometry	MIPL via NAIF
INST_AZ_ROTATION_DIRECTION	Indicates whether the azimuth camera motor moved in a clockwise or counter clockwise motion to get to its current location. The direction is defined by viewing the instrument from above.	string	CW, CCW	N/A	instrument state	TLM:q_table
INST_CMPRS_BLK_SIZE	Dimension of a block for on-board compression; line dimension of the block is the first element, followed by the sample dimension of the block.	integer (array)	for Rice, (1*n) where n ranges from 4 to 24. for JPEG, (8,8)		compression	TLM:cmpr_block
INST_CMPRS_BLOCKS	Number of blocks used to spatially segment the image file prior to on-board compression.	integer	<any positive value that is the image number of pixels divided by the INST_CMPRS_BLK_SIZE>		compression	MIPL
INST_CMPRS_DESC	Textual description of the instrument compression type, which should include a reference to a journal paper, published text or some other publicly available, published material which definitively describes the on-board compression type.	string		NULL	compression	MIPL

Label Name	Description	type	valid	Default	Property	Source
INST_CMPRS_MODE	Selects on-board compression target of image quality or compression factor in conjunction with Huffman or arithmetic entropy encoding with or without LCT. Odd modes select image quality, while even modes select compression factor as a target. Modes 1,2,5,6 use Huffman encoding; modes 3,4,7,8 use arithmetic encoding. Modes 5 through 8 use LCT; mode 9 defines RICE compression.	integer	[1, 9]	NULL	compression	TLM:type
INST_CMPRS_NAME	The type of on-board compression used for data storage and transmission. Contents of this value should be the full, unabbreviated, non-acronym name of coding or compression type. Examples of encoding types include but are not limited to Integer Cosine Transform (ICT), Block Truncation Coding (BTC), Discrete Cosine Transform (DCT), Joint Photographic Experts Group (JPEG) Standard DCT.	string	RAW HUFFMAN/QUALITY HUFFMAN/RATIO ARITHMETIC/QUALITY ARITHMETIC/RATIO HUFFMAN/QUALITY/LCT HUFFMAN/RATIO/LCT ARITHMETIC/QUALITY/LCT ARITHMETIC/RATIO/LCT RICE PIXEL BLOCKING		compression	MIPL
INST_CMPRS_PARAM	JPEG specific variable. Selects on-board compression rate by image quality or by compression factor, based on selected on-board compression mode.	integer	if compression mode is odd, [1, 99]; if compression mode is even, [2, 225].		compression	TLM:cmpr_data_1, cmpr_data_2
INST_CMPRS_QUALITY	JPEG specific variable If an odd SSI compression mode is used for on-board compression, this is the desired image quality index. If an even SSI compression mode is used, this is the resultant image quality used to reach a desired on-board compression factor.	integer	<any positive number>		compression	EK:SSI_COMP_VALUE

Label Name	Description	type	valid	Default	Property	Source
INST_CMPRS_QUANTZ_TBL_ID	This name or code identifies the reference table used for quantization in the frequency domain for on-board transform compression. This name or code should be specific enough to allow the user of the data to have sufficient information to reference the quantization table used to compress the data.	string	[0, 15]	NULL	compression	TLM:q_tble
INST_CMPRS_QUANTZ_TYPE	Method of quantization used for the output of transform coders.	string	"TABULAR"		compression	MIPL
INST_CMPRS_RATE	Average number of bits needed to represent a pixel for an on-board compressed image.	real	<any positive value>	PDS_FLAOT_NULL	compression	MIPL
INST_CMPRS_RATIO	Ratio in bytes of the original, uncompressed data file length to its compressed form. For example, a compression ratio of 5.00 means that on average, for every five bytes of input data, one byte of on-board compressed data was generated.	real	<any positive value>	PDS_FLOAT_NULL	compression	MIPL
INST_CMPRS_SYNC_BLKS	Rice specific variable. Number of compressed blocks between sync markers.	integer	[1, 1024]	PDS_INT_NA	compression	TLM:sync
INST_EL_ROTATION_DIRECTION	Indicates whether the elevation camera motor moved in a clockwise or counter clockwise motion to get to its current location. The Clockwise rotation is defined as the movement from the NADIR to the Zenith position.	string	CW, CCW		instrument state	TLM:q_table
INSTRUMENT_AZIMUTH_COUNT	Azimuth received from the telemetry, measured in SSI motor step position counts from the low hard stop. SSI only.	integer	[0, 644]	PDS_INT_NA	instrument state	TLM:motor_1_position

Label Name	*Description*	*type*	*valid*	*Default*	*Property*	*Source*
INSTRUMENT_COVER_STATE_ID	Identifies whether the RAC cover was over the optics when the image was exposed. A telemetered stepper_motor_2 value of 9 or more indicates off. RAC only	string	OPEN, CLOSED	N/A	instrument state	TLM:filter_or_cover EK:SSI_MOTOR3_CNTS
INSTRUMENT_DEPLOYMENT_STATE	Defines the position of the SSI mast SSI only	string	STOWED, DEPLOYED	N/A	instrument state	MIPL
INSTRUMENT_ELEVATION_COUNT	Elevation received from telemetry, measured in SSI motor step position counts from the low hard stop. SSI only	integer	[0, 328]	PDS_INT_NA	instrument state	TLM:elevation
INSTRUMENT_FOCAL_LENGTH _COUNT	Raw counts of the focal length stepper motor. RAC only	integer	[0,312]	N/A	instrument state	TLM:motor_1_position
INSTRUMENT_HOST_NAME	Full, unabbreviated name of a spacecraft.	string	"MARS POLAR LANDER"		identification	PDS
INSTRUMENT_ID	Acronym of instrument name	string	SSI, RAC		identification	PDS
INSTRUMENT_MODE_ID	Provides an identification for a particular instrument frame. The SSI camera nominally operates in a mode where both the left and right images are exposed and transferred into the frame buffer. Then either the RIGHT, LEFT or BOTH frames are transmitted. Does not apply to RAC EDRs	string	LEFT , RIGHT , BOTH , NONE ,	NULL N/A (RAC)	command	EK:SSI_FRAME_TYPE
INSTRUMENT_NAME	Full name of an instrument.	string	“SURFACE STEREO IMAGER” "ROBOTIC ARM CAMERA"		identification	PDS

Label Name	Description	type	valid	Default	Property	Source
INSTRUMENT_TEMPERATURE	The raw temperature counts of the SSI and RAC in Celsius. The SSI measurements are: • CCD • Bench • CCD _Rear. The RAC measurements are: • CCD • Focus_Motor Measured in Kelvin, saved in Celsius.	real array(3) or array(2)	<any value>		instrument state	MIPL
INSTRUMENT_TEMPERATURE_COUNT	The raw temperature counts of the SSI and RAC in DN with conversion factor of 0.083 degrees Kelvin per DN. The SSI measurements are: • CCD • Bench • CCD _Rear. The RAC measurements are: • CCD • Focus_Motor	real array(3) or array(2)	[0, 4095]		instrument state	TLM:ccd_temperature, camera_head_temp, ccd_rear_temp
INSTRUMENT_TYPE	The instrument_type element identifies the type of an instrument.	string	"IMAGING_CAMERA"		identification	PDS
INSTRUMENT_VERSION_ID	Identifies the instrument used to obtain the data. This could be flight, engineering, prototype, etc.	string	"FM" or "EM" based on phase of the mission. FM is used for OPS, ATLO and instrument check outs (ICO), EM is used for all the rest.		identification	MIPL
LAMP_STATE_ID	Indicates which RAC Lamps were on. Does not apply to SSI EDRs	string	BLUE GREEN RED OFF	NULL N/A (SSI)	command	EK:SSI_FRAME_TYPE

Label Name	Description	type	valid	Default	Property	Source
LANDER_INSTRUMENT_AZIMUTH	Identifies the azimuth pointing of the instrument in the lander coordinate system in degrees.	float		PDS_FLOAT_NULL	derived geometry	MIPL TLM:motor_1_position
LANDER_INSTRUMENT_ELEVATION	Identifies the elevation pointing of the instrument in the lander coordinate system in degrees.	float		PDS_FLOAT_NULL	derived geometry	MIPL TLM:elevation
LOCAL_TRUE_SOLAR_TIME	Reference time based on the IAU standard for the Martian prime meridian. For detailed description, see the Report of the IAU/IAG/COSPAR Working Group on Cartographic Coordinates and Rotational Elements of the Planets and Satellites: 1991. This value is only computed for post landing images.	string	hh:mm:ss	N/A	image geometry	MIPL via NAIF
MAX_AUTO_EXPOS_ITERATION_COUNT	Specifies the number of expose iterations the instrument will perform in order to obtain the requested auto exposure.	integer	[0,5]	PDS_INT_NULL	command	EK:SSI_AUTO_EXP_CNT
MAXIMUM	The maximum DN value in the image file, between the SSI CCD valid range (0 to 4095).	string	[0.0, 8190.0]		image data	MIPL TLM:max_val
MEAN	The mean pixel value for the pixels within the valid DN range.	real	[0.0, 8190.0]		image data	MIPL TLM:mean
MEDIAN	The median pixel value for the pixels within the valid DN range. This value will be at most 8 DN greater than or equal to the true median value.	real	[0.0, 8190.0]		image data	MIPL
MINIMUM	The minimum DN value in the image file, between the SSI CCD valid range (0 to 4095).	string	[0.0, 8190.0]		image data	MIPL TLM:min_val
MISSION_NAME	The planetary mission or project.	string	"MARS SURVEYOR 98"		identification	PDS
MISSION_PHASE_NAME	The mission_phase_name element provides the commonly-used identifier of a mission phase.	string			identification	MIPL

Label Name	Description	type	valid	Default	Property	Source
MODEL_COMPONENT_1_VECTOR	Position of the entrance pupil point of the camera lens (focal center) measured relative to the MVACS coordinate frame. Corresponds to the C vector in the CAHVOR camera model.	real array(3)			derived camera model	MIPL
MODEL_COMPONENT_2_VECTOR	A unit vector **A** in the direction in which the camera is pointed; the direction of the symmetry axis of the camera lens as measure in the MVACS coordinate frame. Corresponds to the A vector in the CAHVOR camera model.	real array(3)			derived camera model	MIPL
MODEL_COMPONENT_3_VECTOR	**H** = **H'** + x_C**A**, where **H'** is a unit vector parallel to the x-axis in the camera's image plane, and x_C is the point of intersection of a perpendicular dropped from the exit pupil point of the camera lens. **H', A', V'** are mutually orthogonal. All the vectors are defined in the MVACS coordinate frame. Corresponds to the H vector in the CAHVOR camera model.	real array(3)			derived camera model	MIPL
MODEL_COMPONENT_4_VECTOR	**V** = **V'** + y_C**A**, where **V'** is a unit vector parallel to the y-axis in the camera's image plane, and y_C is the point of intersection of a perpendicular dropped from the exit pupil point of the camera lens. **H', A', V'** are mutually orthogonal. All the vectors are defined in the MVACS coordinate frame. Corresponds to the V vector in the CAHVOR camera model.	real array(3)			derived camera model	MIPL
MODEL_COMPONENT_5_VECTOR	All the vectors are defined in the MVACS coordinate frame Corresponds to the O vector in the CAHVOR camera model.	real array(3)			derived camera model	MIPL

Label Name	*Description*	*type*	*valid*	*Default*	*Property*	*Source*
MODEL_COMPONENT_6_VECTOR	All the vectors are defined in the MVACS coordinate frame Corresponds to the R vector in the CAHVOR camera model.	real array(3)			derived camera model	MIPL
MODEL_COMPONENT_ID	A sequence identifying the vectors included in this specific model; ex. (C, A, H, V, O, R, E)	string array(6)			derived camera model	MIPL
MODEL_COMPONENT_NAME	A sequence of names, correlated to the model_component_id, identifying the vectors; ex. ("CENTER", "AXIS", "HORIZONTAL", "VERTICAL", "OPTICAL", "RADIAL", "ENTRANCE")	string array(6)			derived camera model	MIPL
MODEL_COMPONENT_UNIT	Defines the real world units the component values are stored as.	string array(6)			derived camera model	MIPL
MODULE_ID	The seq_id element provides an identification of the spacecraft sequence associated with the given product. By convention, this is the first 4 digits of the IMAGE_ID	string			identification	MIPL TLM:image_id
MODULE_VERSION_ID	Digits 5 and 6 of the IMAGE_ID	string			identification	TLM:image_id
MVACS_INSTRUMENT_AZIMUTH	Azimuth of camera at which image scene was captured, measured in degrees clockwise with respect to the Y_I axis of the MVACS frame. See section 1.4 RAC value is based on the Robotic Arm model and the RAC instrument position (INSTURMENT_POSITION_VECTOR)	real	[0, 360.0]		derived geometry	MIPL TLM:motor_1_position

Label Name	*Description*	*type*	*valid*	*Default*	*Property*	*Source*
MVACS_INSTRUMENT_ELEVATION	Elevation of camera at which image scene was captured, measured in degrees with respect to the XY plane of the MVACS FRAME Positive degrees are measured above the XY plane (negative Z direction). See section 1.4 It is possible for this value to change post processing if more accurate pointing is known.	real	[-90.0, 90.0]		derived geometry	MIPL TLM:elevation
MVACS_INSTRUMENT_POSITION	X, Y and Z position of the Robotic Arm Camera, measured in meters in MVACS frame. It is possible for this value to change post processing if more accurate pointing is known.	real array(3)		(0,0,0.8,0)(SSI) NULL (RAC)	derived geometry	MIPL TLM:pointing_vector
MVACS_LOCAL_LEVEL_QUATERNION	A set of four values that define the rotation from MVACS frame to Local Level.	double array(4)		(0,0,0,0)	derived geometry	MVACS
PACKET_CREATION_SCLK	SCLK from the primary telemetry packet header of the 1st packet of the image. Used for requesting image packets from TDS.	string			telemetry	MIPL TLM:image_time
PACKET_MAP_MASK	Identifies the packets that were used to create the image file. The field is a character string of hexadecimal number. The digits of the number correspond with the relative packet number for the image file. The first digit of the number (left-most) corresponds to the first packet of the image. The number is stored in the PDS radix notation: <radix>#<value>#	string			telemetry	MIPL

Label Name	Description	type	valid	Default	Property	Source
PACKET_SEQUENCE_NUMBER	A decimal number that is the 16-bit packet sequence counter from the primary packet header of the sequentially first packet number received for the image.	integer			telemetry	GDS
PHASE_ANGLE	The phase_angle element provides a measure of the relationship between the instrument viewing position and incident illumination (such as solar light). Phase_angle is measured at the target; it is the angle between a vector to the illumination source and a vector to the instrument. If not specfied, the target is assumed to be at the center of the instrument field of view. If illumination is from behind the instrument, phase_angle will be small. See appendix D for more detail. Computed value corresponds to the center pixel and will be saved in the EDR post real-time.	real		PDS_FLOAT_NULL	image geometry	MIPL
PIXEL_AVERAGING_HEIGHT	Block height for pixel averaging prior to image compression.	integer	[1, 9] required that mod(LINES / (PIXEL_AVERAGING_HEIGHT)) = 0	PDS_INT_NULL	compression	TLM:PIX_BLOCK_SIZE_V
PIXEL_AVERAGING_WIDTH	Block width for pixel averaging prior to image compression.	integer	[1, 9] required that mod(SAMPLES / (PIXEL_AVERAGING_WIDTH)) = 0	PDS_INT_NULL	compression	TLM:PIX_BLOCK_SIZE_H
PLANET_DAY_NUMBER	The Martian day on which the image was taken. This is a counter that starts with '0' as the first day of surface operations. No computed for images with SCLKs prior to landing.	real	<any positive value>	PDS_FLOAT_NA	identification	MIPL via NAIF

Label Name	Description	type	valid	Default	Property	Source
POSITIVE_ELEVATION_DIRECTION	The direction in which elevation is measured in positive degrees for an observer on the surface of a body. The elevation is measured with respect to the azimuthal reference plane. A value of UP indicates that the elevation is measured positively upwards, i.e., the zenith point would be at +90 degrees and the nadir point at -90 degrees. DOWN indicates that the elevation is measured positively downwards; the zenith point would be at -90 degrees and the nadir point at +90 degrees.	string	UP		derived geometry	MIPL
PROCESSING_HISTORY_TEXT	Textual summation that provides an entry for each processing step and program used in generating a particular data file in the context of the Ground Data System.	string	"MIPS REALTIME"	NULL	identification	MIPL
PRODUCER_FULL_NAME	Full, unabbreviated name of the individual mainly responsible for the production of the data set.	string	“PAYAM ZAMANI”		identification	MIPL
PRODUCER_ID	Short name or acronym for the producer or producing team/group of a data set.	string	"MIPS OF JPL"		identification	MIPL
PRODUCER_INSTITUTION_NAME	Identifies the institution associated with the production of the data set.	string	“MULTIMISSION IMAGE PROCESSING SUBSYSTEM, JET PROPULSION LAB”		identification	MIPL
PRODUCT_CREATION_TIME	Defines the UTC time when a product was created.	time	YYYY-MM-DDThh:mm:ss.fffZ		identification	MIPL
PRODUCT_ID	A permanent, unique identifier assigned to a data product by its producer.	string	"<RAC | SSI>_EDR-<SCLK_start_count>-<first character of the frame_id>-<image id>"		identification	MIPL
PRODUCT_VERSION_ID	Identifies the version of the EDR. Matches this document's version number.	string	"MPL EDR V2.2"		identification	MIPL
RECEIVED_PACKETS	Total number of telemetry packets which constitute the reconstructed image.	integer	<any positive value>		telemetry	MIPL

Label Name	*Description*	*type*	*valid*	*Default*	*Property*	*Source*
REQUEST_DESCRIPTION	Textural value which identifies the sequence. This value is saved post R/T.	string		NULL	command	MVACS
REQUEST_ID	Number portion of the E-Kernel value for SEQUENCE_ID. Digits between the last "_" and "$" .	string		NULL	command	EK:SSI_SEQUENCE_ID
REQUEST_NAME	Full value of the E-Kernel value for SEQUENCE_ID	string		NULL	command	EK:SSI_SEQUENCE_ID
RICE_OPTION_VALUE	RICE compressor specific variable.	integer	between 2 and (data precision - start_option + 1)	N/A	compression	TLM:cmpr_data_2
RICE_START_OPTION	RICE compressor specific variable.	integer	between 0 and the data precision of pixels	N/A	compression	TLM:cmpr_data_1
SHUTTER_EFFECT_CORRECTION_FLAG	Indicates whether or not the shutter, or fixed-pattern removal command was issued to the flight software. If set TRUE, the image is to be adjusted by an on-board algorithm.	string	TRUE, FALSE		command	EK:SSI_SHUTTER_FLAG
SOFTWARE_NAME	Identifies the name of the telemetry processing software used to generate the image data.	string	"M98TELEMPROC"		telemetry	MIPL
SOFTWARE_VERSION_ID	Identifies the version of the telemetry processing software used to generate the image data.	string			telemetry	MIPL

Label Name	*Description*	*type*	*valid*	*Default*	*Property*	*Source*
SOLAR_LONGITUDE	The solar_longitude element provides the value of the angle between the body_Sun line at the time of interest and the body_Sun line at the vernal equinox. This provides a measure of season on a target body, with values of 0 to 90 degrees representing northern spring, 90 to 180 degrees representing northern summer, 180 to 270 degrees representing northern autumn and 270 to 360 degrees representing northern winter. Value not computed for images with SCLKs prior to landing.	real		PDS_FLOAT_NA	image geometry	NAIF
SPACECRAFT_CLOCK_CNT_PARTITION	Database partition identifier. This is used to identify the cycle of spacecraft clock for the current data. It's value is set manually via m98telemproc and the DB administration.	positive integer			identification	TLM:image_time
SPACECRAFT_CLOCK_START_COUNT	Lander time in seconds at which the image was acquired. Image Generation Time in the SSI Telemetry Format specification from the U. of Arizona. Corresponds to IMAGE_TIME.	string			identification	TLM:image_time
SPACECRAFT_CLOCK_STOP_COUNT	Lander time in seconds at which the image was acquired. Image Generation Time in the SSI Telemetry Format specification from the U. of Arizona. Corresponds to IMAGE_TIME. This label item is required by PDS. It's value will be equal to SPACECRAFT_CLOCK_START_COUNT	string			identification	MIPL

Label Name	Description	type	valid	Default	Property	Source
SPICE_FILE_NAME	Filenames of SPICE kernels used to produce image data and derived data.	string array(6)	comma separated standard SPICE kernel names in order: E, SLCK, leapsecond, SPK, PCK, surface If a value is unknown, "NULL" will be saved for that file.		image data	MIPL
SQRT_COMPRESSION_FLAG	Indicates whether or not the square root compression command was issued to the flight software. If set TRUE, the image is to be square root compressed on-board from a 12 bit pixel down to an 8 bit pixel.	string	TRUE, FALSE	NULL	command	EK:SSI_SQRT_FLAG TLM:max_val (msb)
SQRT_MAXIMUM_PIXEL	Maximum pixel value in 12-bit image prior to square root compression.	integer	[0, 4095]		compression	TLM:max_val (lsb)
SQRT_MINIMUM_PIXEL	Minimum pixel value in 12-bit image prior to square root compression.	integer	[0, 4095]	PDS_INT_NULL	compression	TLM:min_val (lsb)
SRFC_FXD_LCL_LVL_VECTOR	An (array) of X, Y, and Z offsets in meters from Mars Surface Fixed frame to the origin of the Local Level measured in surface fixed frame.	real array(3)	NA	(0,0,0)	derived geometry	MVACS
STANDARD_DEVIATION	Standard deviation of the valid pixel values around the mean DN value.	real	[0.0, 4095.0]		image data	MIPL
START_TIME	UTC corresponding to the first line of the image	string			identification	TLM:image_time
STOP_TIME	UTC corresponding to the last line of the image	string			identification	TLM:image_time
SURFACE_FIXED_INST_AZIMUTH	Azimuth of the camera measured in the Mars Surface Fixed frame (MFX frame). Azimuth is measured positively in degrees clockwise from the Martian north (spin axis), projected onto the local gravity horizontal plane (plane perpendicular to the gravity vector). Also generally known as NORTH_AZIMUTH. See section 1.4	real	[0.0, 360.0]		derived geometry	MIPL

Label Name	Description	type	valid	Default	Property	Source
SURFACE_FIXED_INST_ELEVATION	Elevation of the camera measured in the Mars Surface Fixed frame (MFX frame). Elevation is measured in degrees up from the Mars Local Level or Surface Fixed X,Y plane (negative Z direction). See section 1.4	real	[-90.0, 90.0]		derived geometry	MIPL
SURFACE_FIXED_SOLAR_AZIMUTH	Where to look in the azimuth direction to see the sun (ability to see the sun at night assumes a clear planet) Value not computed for images with SCLKs prior to landing.	real		PDS_FLOAT_NA	image geometry	NAIF
SURFACE_FIXED_SOLAR_ELEVATION	Where to look in elevation direction to see the sun (ability to see the sun at night assumes a clear planet) Value not computed for images with SCLKs prior to landing.	real		PDS_FLOAT_NA	image geometry	NAIF
TARGET_NAME	Identifies a target, be it a planetary body, region or feature. This value will be saved post real-time.	string	NULL		identification	MVACS
TELEMETRY_MVACS_INST_ELEVATION	Angle between the MVACS frame X-Y plane and the RAC frame approach vector with positive elevation pointing down. Units are in radians.	real		PDS_FLOAT_NULL	instrument state	TLM:elevation
TELEMETRY_MVACS_INST_POSITION	X, Y and Z position of the Robotic Arm Camera, measured in meters in MVACS frame.	real array(3)			instrument state	TLM:pointing_vector
TELEMETRY_PROVIDER_ID	Identifies the provider and version of the telemetry data used in the generation of this data.	string		NULL	telemetry	MIPL
TELEMETRY_PROVIDER_TYPE	Identifies the source of the telemetry used in creation of this data set	string	FILE TDS PORT		telemetry	MIPL
TELEMETRY_SOURCE_TYPE	Identifies the source of the telemetry used in creation of this data set	string	SFDU CCSDS_PKTS		telemetry	MIPL

Label Name	Description	type	valid	Default	Property	Source
TLM_CMD_DISCREPANCY_FLAG	Indicator of mismatch(es) found between SSI commands uplinked and SSI telemetry. The fields checked when determining this flag are: • APPPLICATION_PACKET_ID • EXPOSURE_TYPE • FILTER_NUMBER • FRAME_ID • INST_CMPRS_MODE • LINES • LINES_SAMPLES • PIXEL_AVERAGING_HEIGHT • PIXEL_AVERAGING_WIDTH • SQRT_COMPRESSION_FLAG	string	TRUE, FALSE		telemetry	MIPL

Appendix B: Property Labels

Every label described in the Appendix A belongs to a VICAR property label and they are repeated here for convenience, grouped by the property.

Command

AUTO_EXPOSURE_DATA_CUT
AUTO_EXPOSURE_PIXEL_FRACTION
BAD_PIXEL_REPLACEMENT_FLAG
COMMAND_DESC
COMMAND_NAME
DARK_CURRENT_CORRECTION_FLAG
DOWNLOAD_TYPE
FLAT_FIELD_CORRECTION_FLAG
INSTRUMENT_MODE_ID
LAMP_STATE_ID
MAX_AUTO_EXPOS_ITERATION_COUNT
REQUEST_DESCRIPTION
REQUEST_ID
REQUEST_NAME
SHUTTER_EFFECT_CORRECTION_FLAG
SQRT_COMPRESSION_FLAG

Compression

ERROR_PIXELS
INST_CMPRS_BLK_SIZE
INST_CMPRS_BLOCKS
INST_CMPRS_DESC
INST_CMPRS_MODE
INST_CMPRS_NAME
INST_CMPRS_PARAM
INST_CMPRS_QUALITY
INST_CMPRS_QUANTZ_TBL_ID
INST_CMPRS_QUANTZ_TYPE
INST_CMPRS_RATE
INST_CMPRS_RATIO
INST_CMPRS_SYNC_BLKS
PIXEL_AVERAGING_HEIGHT
PIXEL_AVERAGING_WIDTH
RICE_OPTION_VALUE
RICE_START_OPTION
SQRT_MAXIMUM_PIXEL
SQRT_MINIMUM_PIXEL

Derived Camera Model

CALIBRATION_SOURCE_ID
CAMERA_MODEL_DESC
CAMERA_MODEL_NAME
CAMERA_MODEL_TYPE
COORDINATE_SYSTEM_NAME
GEOMETRY_SOURCE_ID
MODEL_COMPONENT_1_VECTOR
MODEL_COMPONENT_2_VECTOR
MODEL_COMPONENT_3_VECTOR
MODEL_COMPONENT_4_VECTOR
MODEL_COMPONENT_5_VECTOR
MODEL_COMPONENT_6_VECTOR
MODEL_COMPONENT_ID
MODEL_COMPONENT_NAME
MODEL_COMPONENT_UNIT

Derived Geometry

DERIVED_GEOMETRY_DESC
DERIVED_GEOMETRY_NAME
DERIVED_GEOMETRY_NOTE
DERIVED_GEOMETRY_TYPE
LANDER_INSTRUMENT_AZIMUTH
LANDER_INSTRUMENT_ELEVATION
MVACS_INSTRUMENT_AZIMUTH
MVACS_INSTRUMENT_ELEVATION
MVACS_INSTRUMENT_POSITION
MVACS_LOCAL_LEVEL_QUATERNION
POSITIVE_ELEVATION_DIRECTION
SRFC_FXD_LCL_LVL_VECTOR
SURFACE_FIXED_INST_AZIMUTH
SURFACE_FIXED_INST_ELEVATION

Identification

DATA_SET_ID
DATA_SET_NAME
FRAME_ID
IMAGE_ID
IMAGE_TIME
IMAGE_TYPE
INSTRUMENT_HOST_NAME
INSTRUMENT_ID
INSTRUMENT_NAME
INSTRUMENT_TYPE
INSTRUMENT_VERSION_ID
MISSION_NAME
MISSION_PHASE_NAME
MODULE_ID
MODULE_VERSION_ID
PLANET_DAY_NUMBER
PROCESSING_HISTORY_TEXT
PRODUCER_FULL_NAME
PRODUCER_ID
PRODUCER_INSTITUTION_NAME
PRODUCT_CREATION_TIME
PRODUCT_ID
PRODUCT_VERSION_ID
SPACECRAFT_CLOCK_CNT_PARTITION
SPACECRAFT_CLOCK_START_COUNT
SPACECRAFT_CLOCK_STOP_COUNT
START_TIME
STOP_TIME
TARGET_NAME

Image Data

BANDS
FIRST_LINE
FIRST_LINE_SAMPLE
MAXIMUM
MEAN
MEDIAN
MINIMUM
SPICE_FILE_NAME
STANDARD_DEVIATION

Image Geometry

EMISSION_ANGLE
INCIDENCE_ANGLE
LOCAL_TRUE_SOLAR_TIME
PHASE_ANGLE
SOLAR_LONGITUDE
SURFACE_FIXED_SOLAR_AZIMUTH
SURFACE_FIXED_SOLAR_ELEVATION

Instrument State

AZIMUTH_FOV
ELEVATION_FOV
EXPOSURE_DURATION
EXPOSURE_DURATION_COUNT
EXPOSURE_TYPE
FILTER_NAME
FILTER_NUMBER
INST_AZ_ROTATION_DIRECTION
INST_EL_ROTATION_DIRECTION
INSTRUMENT_AZIMUTH_COUNT
INSTRUMENT_COVER_STATE_ID
INSTRUMENT_DEPLOYMENT_STATE
INSTRUMENT_ELEVATION_COUNT
INSTRUMENT_FOCAL_LENGTH _COUNT
INSTRUMENT_TEMPERATURE
INSTRUMENT_TEMPERATURE_COUNT
TELEMETRY_MVACS_INST_ELEVATION
TELEMETRY_MVACS_INST_POSITION

Telemetry

APPLICATION_PACKET_ID
APPLICATION_PACKET_NAME
EARTH_RECEIVED_START_TIME
EARTH_RECEIVED_STOP_TIME
EXPECTED_PACKETS
PACKET_CREATION_SCLK
PACKET_MAP_MASK
PACKET_SEQUENCE_NUMBER
RECEIVED_PACKETS
SOFTWARE_NAME
SOFTWARE_VERSION_ID
TELEMETRY_PROVIDER_ID
TELEMETRY_PROVIDER_TYPE
TELEMETRY_SOURCE_TYPE
TLM_CMD_DISCREPANCY_FLAG

Appendix C: PDS null and default definition

The PDS definitions for null and default values are contained in a "C" include header file names pds_nulls.h. The content of this file, at the time of publication is included below. Although it is possible for these values to change over time, no changes are expected for the duration of the Mars Polar lander's mission life.

To obtain the latest version of this file, please see the heading comment of the file below.

```
/*****************************************************************************
***                                                                        ***
***                            pds_nulls.h                                 ***
***                                                                        ***
*** Author:       Elizabeth Duxbury (Elizabeth.Duxbury@jpl.nasa.gov)       ***
***                                                                        ***
*** Purpose:      Defines PDS N/A, UNK, and NULL values for various        ***
***               data types.                                              ***
***                                                                        ***
*** Usage:        (taken from "Planetary Data System Standards             ***
***               Reference, Version 3.2, Chapter 17")                     ***
***                                                                        ***
***               "N/A" (shorthand for "Not Applicable") indicates         ***
***               that the values within the domain of this data           ***
***               element are not applicable in this instance.             ***
***                                                                        ***
***               "UNK" (shorthand for "Unknown") indicates that the       ***
***               value for this data element in this instance is          ***
***               permanently not known.  A value is applicable but        ***
***               none is forthcoming.                                     ***
***                                                                        ***
***               "NULL" indicates that the value for this data            ***
***               element in this instance is temporarily unknown.         ***
***               A value is applicable and is forthcoming.                ***
***                                                                        ***
*** Notes:                                                                 ***
***                                                                        ***
*** Last Updated: 06/06/97                                                 ***
***                                                                        ***
*****************************************************************************
***                                                                        ***
*** Copyright (c) 1997, Jet Propulsion Laboratory, California             ***
*** Institute of Technology.                                              ***
***                                                                        ***
*** "This work was performed for the Jet Propulsion Laboratory,           ***
*** California Institute of Technology, sponsored by the United           ***
*** States Government under Contract NAS7-1260."                          ***
***                                                                        ***
*****************************************************************************/

#ifndef _PDS_NULLS_H
#define _PDS_NULLS_H

#ifdef __cplusplus
extern "C" {
#endif

#include <limits.h>

#define PDS_STRING_NA         "N/A"          /* string N/A */
#define PDS_STRING_UNK        "UNK"          /* string UNK */
#define PDS_STRING_NULL       "NULL"         /* string NULL */

#define PDS_CHAR_NA           (-127)         /* char N/A */
#define PDS_CHAR_UNK          (-128)         /* char UNK */
#define PDS_CHAR_NULL         0              /* char NULL */

#define PDS_UCHAR_NA          254            /* unsigned char N/A */
#define PDS_UCHAR_UNK         255            /* unsigned char UNK */
#define PDS_UCHAR_NULL        0              /* unsigned char NULL */
```

```
#define PDS_SHRT_NA           (-32768)       /* short int N/A */
#define PDS_SHRT_UNK          32767          /* short int UNK */
#define PDS_SHRT_NULL         (-32767)       /* short int NULL */

#define PDS_USHRT_NA          65533          /* unsigned short int N/A */
#define PDS_USHRT_UNK         65534          /* unsigned short int UNK */
#define PDS_USHRT_NULL        65532          /* unsigned short int NULL */

#define PDS_LONG_NA    (-2147483647L-1L)     /* long int N/A */
#define PDS_LONG_UNK   2147483647L           /* long int UNK */
#define PDS_LONG_NULL  (-2147483647L)        /* long int NULL */

#define PDS_ULONG_NA          4294967294UL   /* unsigned long int N/A */
#define PDS_ULONG_UNK         4294967295UL   /* unsigned long int UNK */
#define PDS_ULONG_NULL        4294967293UL   /* unsigned long int NULL */

#define PDS_INT_NA            PDS_LONG_NA    /* int N/A; machine dependent */
#define PDS_INT_UNK           PDS_LONG_UNK   /* int UNK; machine dependent */
#define PDS_INT_NULL          PDS_LONG_NULL  /* int NULL; machine dependent */

#define PDS_UINT_NA           PDS_ULONG_NA   /* unsigned int N/A; machine dep. */
#define PDS_UINT_UNK          PDS_ULONG_UNK  /* unsigned int UNK; machine dep. */
#define PDS_UINT_NULL         PDS_ULONG_NULL /* unsigned int NULL; machine dep. */

#define PDS_FLOAT_NA          (-1.0e32F)     /* float N/A */
#define PDS_FLOAT_UNK         1.0e32F        /* float UNK */
#define PDS_FLOAT_NULL        (-0.999e32F)   /* float NULL */

#define PDS_DOUBLE_NA         PDS_FLOAT_NA   /* double N/A */
#define PDS_DOUBLE_UNK        PDS_FLOAT_UNK  /* double UNK */
#define PDS_DOUBLE_NULL       PDS_FLOAT_NULL /* double NULL */

#ifdef __cplusplus
}
#endif

#endif _PDS_NULLS_H
```

Appendix D: Algorithms

FIRST_LINE

Indicates the line within a source image that corresponds to the first line of the sub-image.

Value obtained from E-Kernel for all images except ATMOSPHERIC images. For those, value is calculated based on algorithm supplied by UA and LPL.

Note: EK value is 0 based. EDR will be 1 based.

FIRST_LINE SAMPLE

Indicates the sample within a source image that corresponds to the first sample in the sub-image.

Value obtained from E-Kernel for all images except ATMOSPHERIC images. For those, value is calculated based on algorithm supplied by UA and LPL.

Note: EK value is 0 based. EDR will be 1 based.

EMISSION_ANGLE

The emission_angle element provides the value of the angle between the surface normal vector at the intercept point and a vector from the intercept point to the spacecraft.

The emission_angle varies from 0 degrees when the spacecraft is viewing the subspacecraft point (nadir viewing) to 90 degrees when the intercept is tangent to the surface of the target body. Thus, higher values of emission_angle indicate more oblique viewing of the target. Values in the range of 90 to 180 degrees are possible for ring data.from pixel to pixel.

Only the value for the center pixel is estimated and saved. For this EDR, the value is defined to be surface fixed frame instrument elevation + 90 degrees.

INCIDENCE_ANGLE

Incidence angle is the angle between the local vertical at the intercept point (surface) and a vector from the intercept point to the sun.
Only the value for the center pixel of the image is computed. A flat surface is assumed.
For this EDR, the value is defined to be SURFACE_FIXED_SOLAR_AZIMUTH - 90 degrees

PHASE_ANGLE

The phase_angle element provides a measure of the relationship between the instrument viewing position and incident illumination (such as solar light). Computed value corresponds to the center pixel.

Computation per Mark Lemmon from U of A is as follow:

e = emission angle

i = incidence angle (0 for the Sun at zenith, 90 at horizon)
d = delta_azimuth = angle between the emission azimuth and the incidence azimuth expressed as an angle between 0 and 180 degrees (or 0 to pi radians) emission az = -(local_level_azimuth)
[To picture this, d is the angle on our level surface between the azimuth of the camera and the azimuth of the Sun as viewed from the target (our single pixel on that level surface).]

dot_phase = sin(e) * sin(i) * cos(d) + cos(e) * cos(i)
phase_angle = acos(dot_phase)

Serving size: a single floating point number between 0 and 180 degrees

To picture it, this is the angle in the Sun-target-camera plane between the Sun and the camera as seen by the target.